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Traffic Information Requirements For Estimates of Highway Impact On Air Quality

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16. ABSTRACT

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This manual is the third in a series of six manuals, the titles of which follow:

1. Meteorology and Its Influence on the Dispersion of Pollutants from Highway Line Sources.
2. Motor Vehicle Emission Factors for Estimates of Highway Impact on Air Quality.
3. Traffic Information Requirements for Estimates of Highway Impact on Air Quality.
4. Mathematical Approach to Estimating Highway Impact on Air Quality.
5. Analysis of Ambient Air Quality for Highway Environmental Projects.
6. A Method for Analyzing and Reporting Highway Impact on Air Quality.

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TRAFFIC INFORMATION REQUIREMENTS FOR ESTIMATES OF HIGHWAY IMPACT ON AIR QUALITY

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Revised April 1974

FOREWORD

A number of studies must be completed prior to the writing of an Environmental Impact Statement for a highway project. One of these studies is concerned with the gathering of field data, analysis of such data, and writing an air quality report.

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The material presented in these manuals is subject to change as further research provides information. The following items are not discussed or, if presented, are subject to care in the interpretation of results.

1. There are no statistically validated photochemical models for different meteorological conditions which will permit calculations of oxidant formed downwind from a line source.

2. Further research is required to fully validate model calculations when winds blow parallel to the line source.

ACKNOWLEDGEMENTS

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The assistance of Messrs. Karl Moskowitz and Fred Rooney of the Headquarters Traffic Department and Mr. Gib Fairman of Headquarters Urban Planning Office in discussing and contributing to the concepts underlying this report is greatly appreciated.

This work was accomplished in cooperation with the United States Department of Transportation, Federal Highway Administration. The opinions, findings, and conclusions expressed in this publication are those of the California Division of Highways and not necessarily those of the Federal Highway Administration.

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INTRODUCTION

Transportation improvements cause changes in the existing traffic network. These changes affect air quality in so far as they affect vehicle operating modes, volumes, and miles traveled.

Emissions from vehicles, unlike those from most stationary sources, are not governed by a tightly controlled combustion process and, usually, are in a constant state of flux. These changes in the combustion process, and their consequent reflection in pollutant emissions, are caused by changes in the mode of vehicle operation. Other things being equal, it is obvious that emissions vary directly with traffic volume and miles traveled.

Variations in vehicular pollutant emissions resulting from changes in the above parameters affect, in a general sense, the overall air pollution burden and, in a specific sense, the receptors immediately downwind from the traffic facility.

Any study, therefore, which will characterize highway impact on air quality, must be founded on traffic estimates which describe changes in an areal traffic network in terms of operating mode, traffic volume, and miles traveled.

Additional factors necessary for such an analysis include a consideration of traffic growth and some time period over which the analysis should be made. It is also necessary to understand the relationship between the traffic parameters and the way in which air quality is affected. Pointing out this relationship is one of the main objects of this manual.

VEHICLE OPERATING MODE AND POLLUTANT EMISSION

Vehicles traveling on freeways during off peak hours, in the absence of accident-caused congestion, operate generally at a steady-state speed. This speed, depending on the prevailing volume/capacity ratio (V/C), may range between forty and seventy miles per hour according to the Highway Capacity Manual(1). Other studies(2) indicate that, under free flow conditions, speeds seldom fall below fifty-five miles per hour.

According to recent data(3), based on very limited test results on late model cars, going from a steady state speed of forty miles per hour to one of seventy miles per hour may cause a 65% increase in carbon monoxide emissions and a 120% increase in nitric oxide emissions while hydrocarbon emissions remain relatively unaffected.

The effect of speed changes on surface traffic, however, is substantially different. Traffic on surface streets, except for those vehicles riding in a "through band" or "progressive platoon", is subjected to acceleration, deceleration, periods of idle, and short periods of "steady-state", or cruise, operation. Congested peak-hour traffic on certain freeways may also exhibit these characteristics.

Research on emissions for this type of operation has utilized the concept of "average trip speed". Average trip speed, overall travel speed, or journey speed is simply the distance covered divided by the elapsed time. Average trip speed on urban and suburban arterials with uncoordinated signals and a twenty-five mph speed limit will normally range between fifteen and twenty-two mph(1). Downtown streets may operate at the lower limit of stable flow conditions with an overall travel speed of about ten mph(1). Rose(4) who studied urban surface traffic emissions in two cities found average trip speeds in the vicinity of ten to twenty-five mph.

When surface traffic volumes are low and signals well synchronized, the periods of acceleration, deceleration, and idle decrease allowing the average trip speed to increase. Increases in average trip speed from ten miles per hour to twenty-five miles per hour may reduce carbon monoxide and hydrocarbon emissions by one-third and increase nitric oxide emissions threefold(3) on late model cars.

Figures 1, 2, and 3 illustrate, in a general manner, the probable relationships between speed and pollutant emissions. The figures represent minimal data from late model vehicles and are presented only as an indication of the actual relationship. It should be noted that older cars, which comprise the largest portion of our

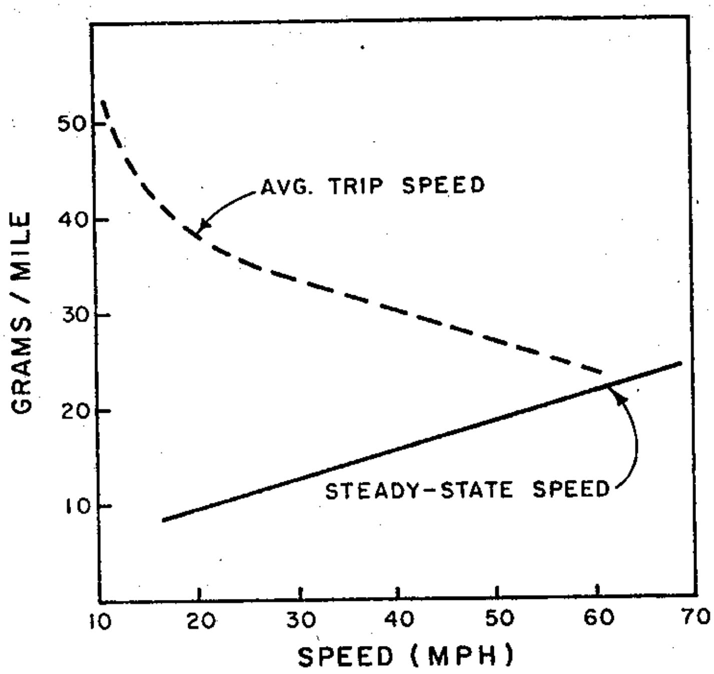

Fig. I CARBON MONOXIDE

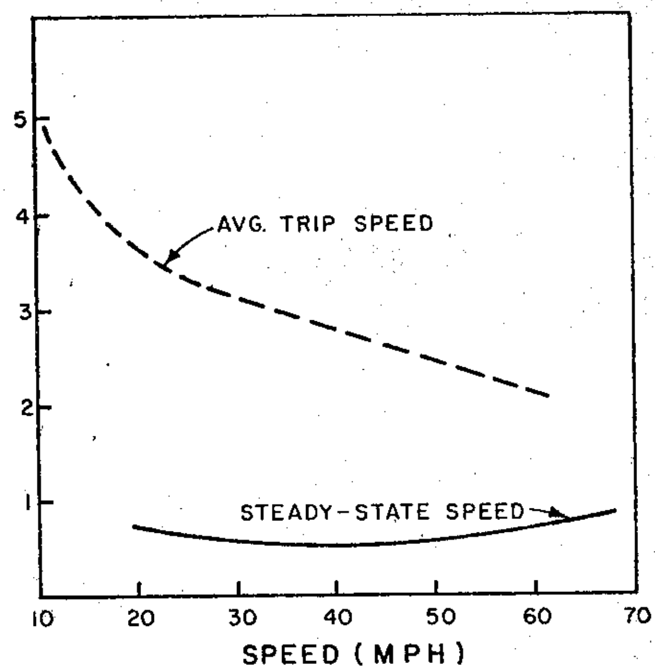

Fig. 2 HYDROCARBONS

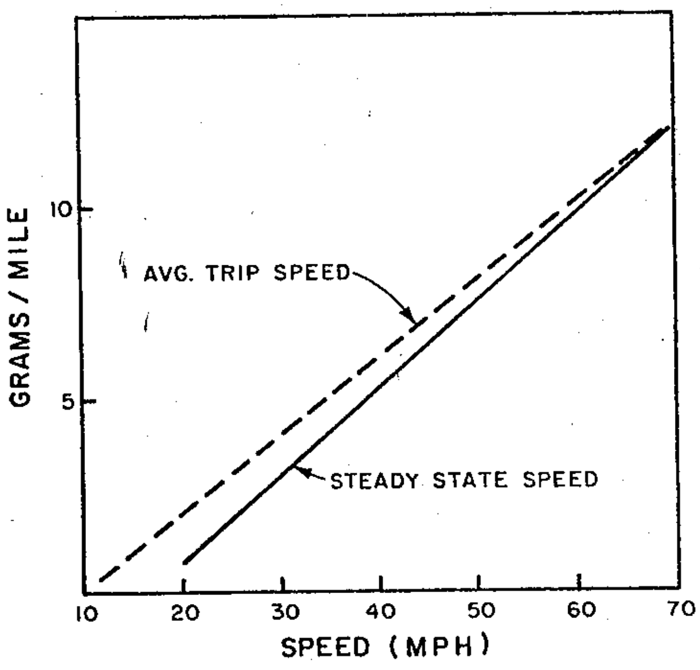

Fig. 3 NITRIC OXIDE

PROBABLE RELATIONSHIP BETWEEN VEHICLE SPEED AND POLLUTANT EMISSION vehicle population, enjoy a greater reduction in carbon monoxide and hydrocarbon emissions with an increase in speed than do newer cars. At the same time, the speed increase has a lesser effect on the increase in nitric oxide emissions(4).

Examination of pollutant emissions at twenty miles per hour in Figures 1-3 indicates that a change in operating mode from average trip speed to steady-state speed may reduce carbon monoxide emissions by a factor of three and one-half and hydrocarbons and nitric oxide by a factor of two. When the average trip speed approaches sixty-five miles per hour, the emissions become equal to those at the steady-state speed.

Starting a cold engine in the morning causes a much greater emission of pollutants than does starting and running a warm engine(5). For this reason, trips which originate within a given areal traffic network generally produce a greater quantity of pollutants, proportionally, than do those trips which originate outside the network and pass through it on the way to their destination.

Generally speaking, vehicles entering freeways have spent enough time on the surface street system to warm their engines so that emissions on the freeway, under equivalent operating modes, are substantially less than those on surface streets.

Practically, differences in emissions resulting from steady-state versus overall trip speed, and cold engines versus warm engines, can be approximated by using one set of emission factors for freeway traffic and another set for surface traffic(6).

When more information on emissions and operating mode is developed, assuming sufficient traffic detail is available, it may be possible to refine the emission calculations. Moves in this direction should attempt to define the number of miles traveled in a particular operating mode so that the appropriate emission factor may be applied to each mode and the results then summed.

The effects of operating mode and speed upon emissions will become less important as more efficient emission controls are applied to vehicles. The vehicle mix constituting typical traffic will, however, contain older vehicles with less efficient controls until about 1990.

VEHICLE VOLUMES

It is readily apparent that pollutant emissions vary directly with traffic volumes. For this reason it is necessary to examine the variations which might be expected to occur in a dynamic traffic network in order to select the most critical conditions for analysis.

Some of the readily apparent fluctuations occurring on both freeways and the surface network are due to hourly, daily, and seasonal changes. Hourly changes in freeway traffic usually vary in a manner similar to those illustrated in Figure 4.

Figure 4 shows, in terms of percent of ADT, the typical motor vehicle travel distribution on urban and rural highways in California by annual average hour of the day(7).

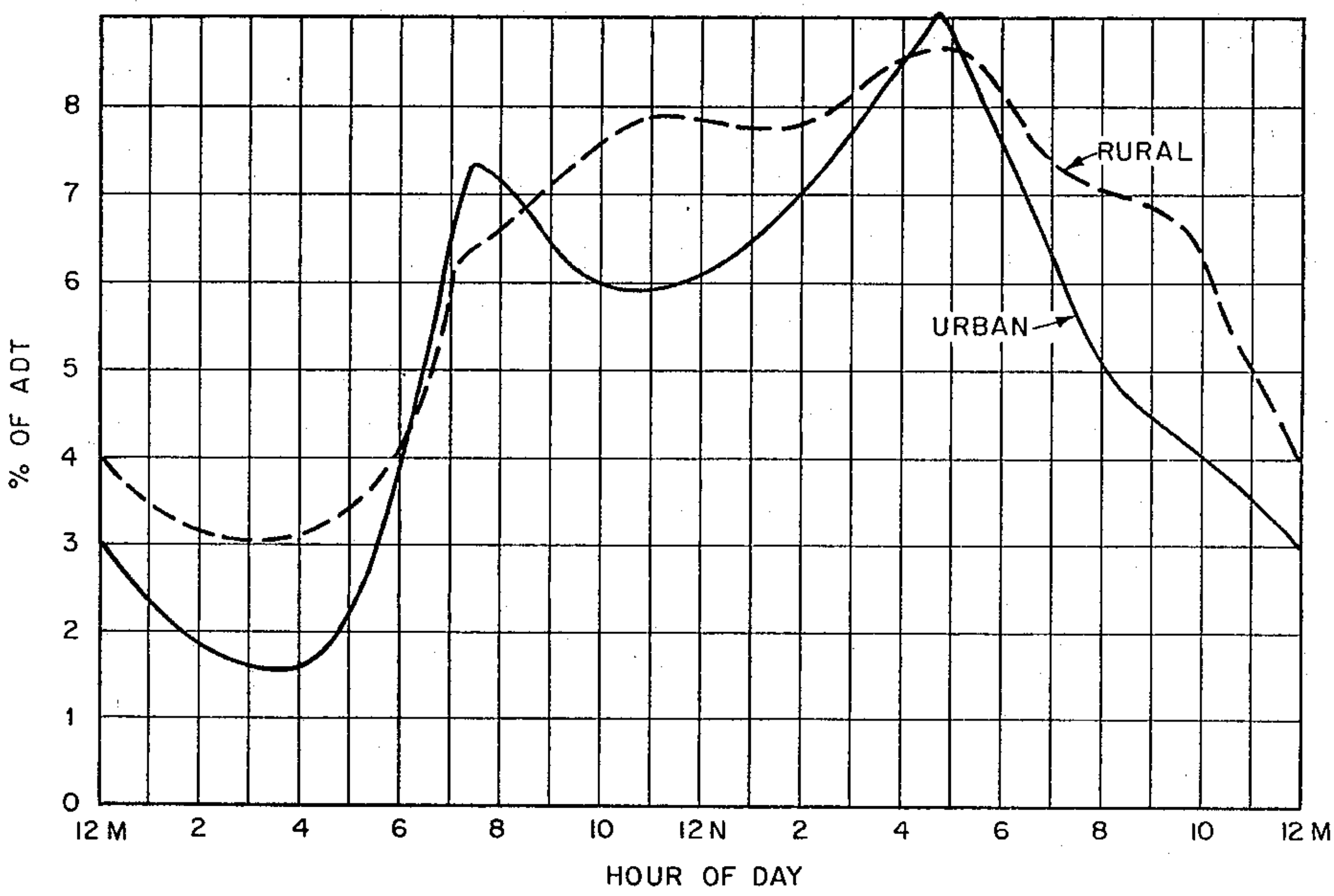

Fig. 4 TYPICAL CALIFORNIA MOTOR VEHICLE TRAVEL DISTRIBUTION BY ANNUAL AVERAGE HOUR OF THE DAY

It may be important, in some cases, to look at the hourly traffic variation on weekends separately from the typical week day variation. Figure 5, adapted from the Highway Capacity Manual (1) shows how these daily variations can look.

In this relationship, the weekday travel is dominated by commuter traffic while the Sunday traffic is no doubt recreational in nature. Even though the three separate peaks are equal in magnitude, temporal changes in meteorology may cause one peak to be more important than the others.

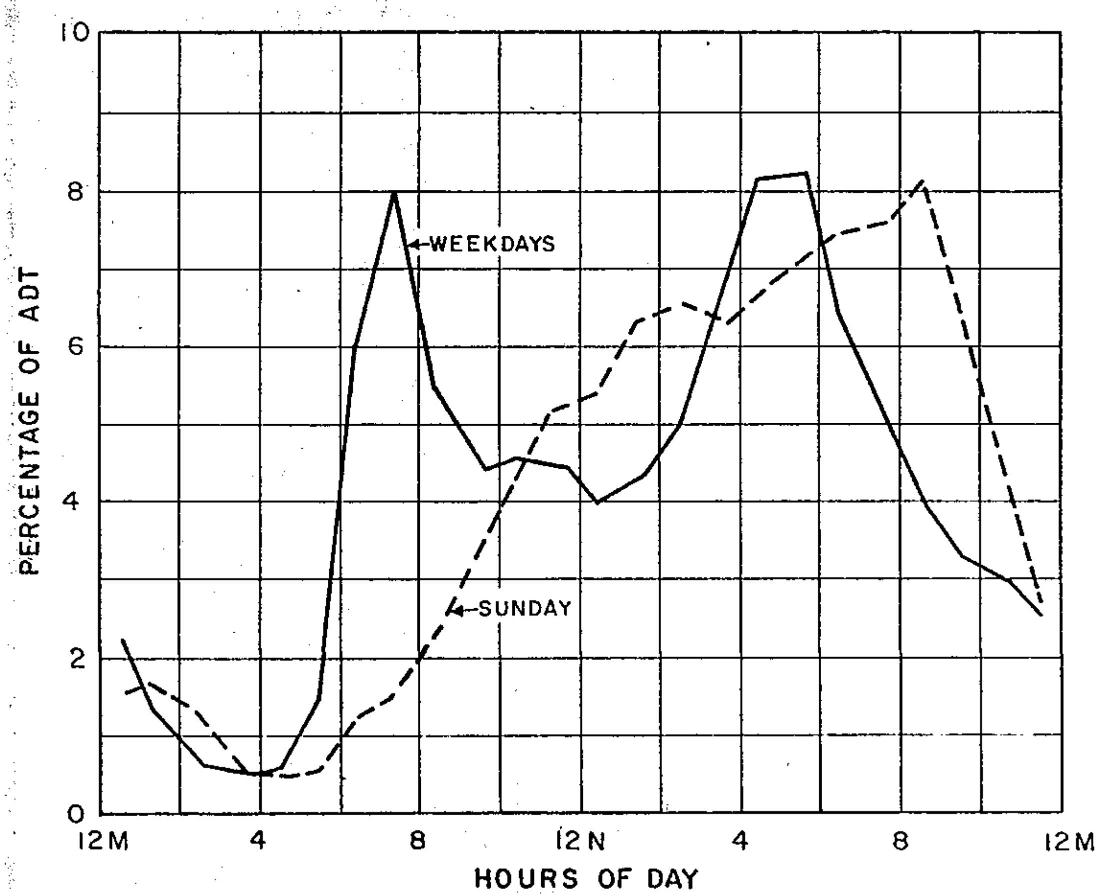

Fig. 5 WEEKDAY VS SUNDAY TRAFFIC

Other daily changes, from the same source(1), are shown in Figure 6. Here the characteristics of urban and rural traffic are contrasted. The urban traffic stays at about the same level during the week, increases as the weekend traffic begins to leave town on Friday, and falls to a low on Sunday. The rural traffic patternis generally opposite.

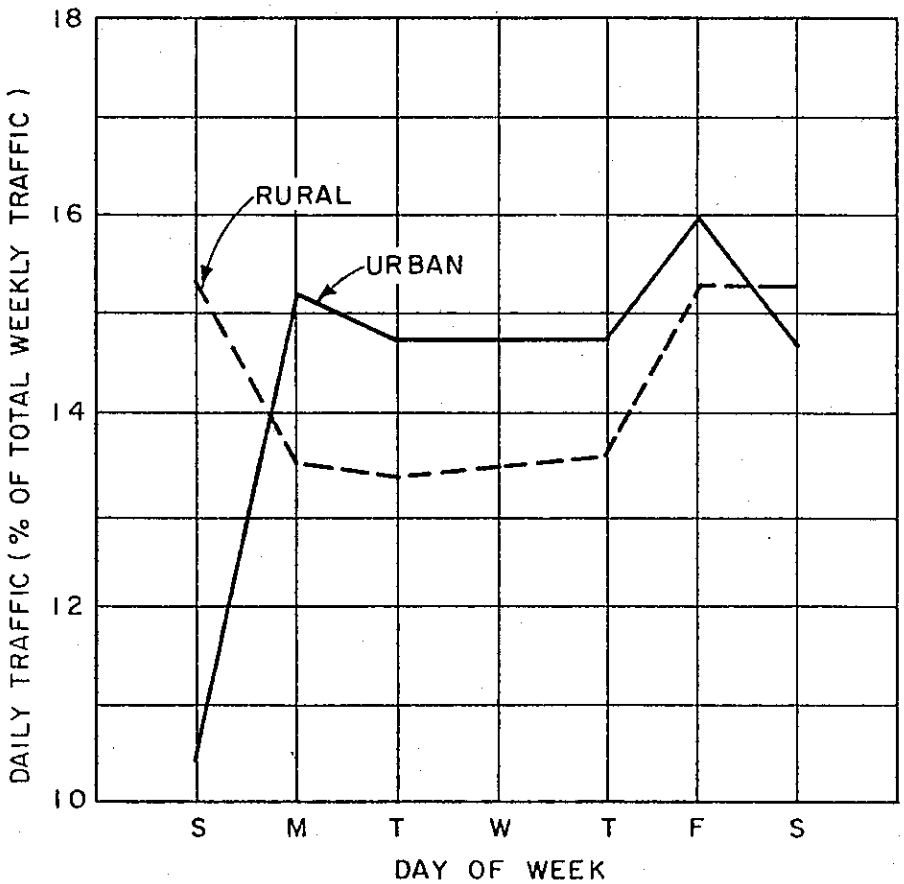

Fig. 6 DAILY CHANGES IN TRAFFIC

Seasonal variations may also be considerable and, due to typical associated meteorological regimes, may be very important, Figure 7, from the Highway Capacity Manual(1), shows variations which may occur.

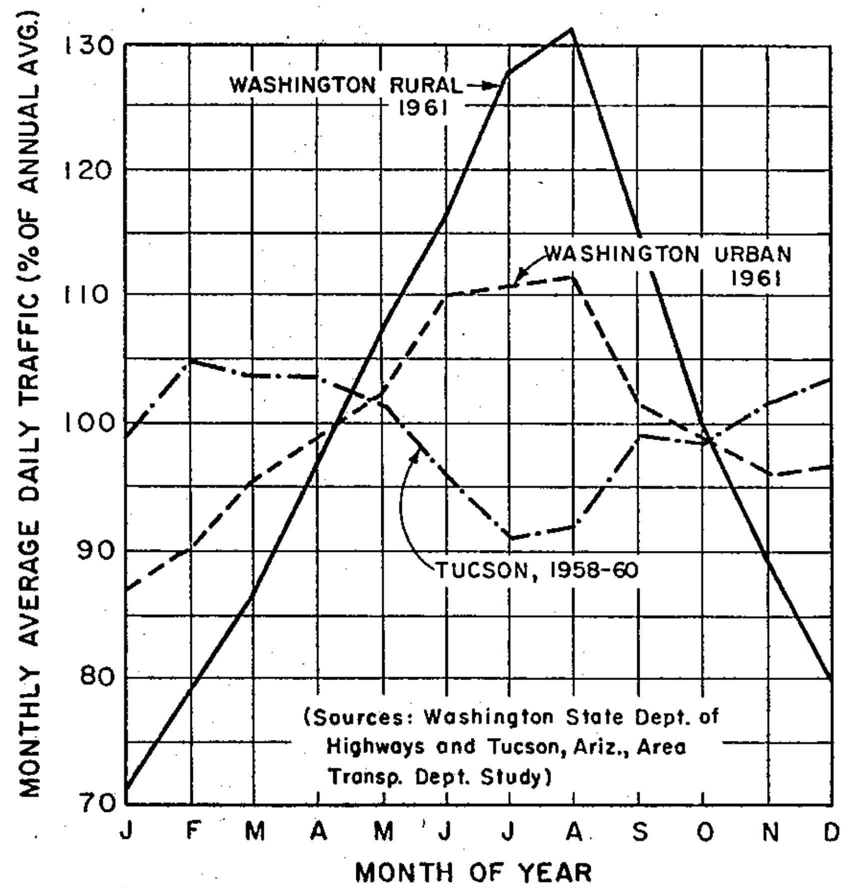

Fig. 7 EXAMPLES OF MONTHLY TRAFFIC VOLUME VARIATIONS

These data, for the State of Washington, show comparatively little seasonal variation in urban traffic and high variation in rural traffic due to recreational travel. Comparing the other urban area, Tuscon, with the Washington urban traffic, the effect of climate can easily be seen.

Inbound and outbound traffic, with respect to the central business district (CBD), in an urban area may have totally different characteristics. During the morning peak, inbound volumes are high and, as the V/C ratio tends toward unity, speeds fall off and congestion may occur. During this same period, the outbound traffic is usually free-running. In the afternoon peak the reverse may occur. It may be important to differentiate between the two directional volumes when calculating emissions since the effect could be considerable. Also, since pollutant dispersion is enhanced by distance, the lateral location of slow moving and congested traffic is important to the immediate downwind receptor, especially on highways with many lanes and wide medians.

TRAFFIC NETWORK CHANGES

When improvements to a traffic network are made, changes in the network occur. These changes can be quantified in terms of volume, speed, and mileage. Accordingly, emission calculations can be made to reflect these changes. A few examples of the type of change to look for are discussed below.

If an improvement, such as a freeway, is built parallel to existing surface arterials, traffic volumes on these arterials will be reduced and overall travel speeds will probably increase. This will have a salutory effect on emissions. At the same time, travel on cross-streets may increase as people try to get on the improved, or new, facility. Since the new route will be more desirable with respect to travel time, people will be willing to travel a little farther to reach it. These alterations in the traffic network may be substantial. If they are substantial, an attempt should be made to quantify the resultant effect on emissions.

Urban transportation plans often include future urban mass transit lines. If future traffic is to be characterized for the purpose of estimating emissions, these improvements must be analyzed. It is entirely possible that poorly planned station locations could engender more local vehicle travel of a stop and go nature. If the stations have insufficient parking, it is probable that a family member will take and pick up the commuter. In this event the mileage traveled will be double that if the vehicle were parked at the station. For one-car families, urban mass transit systems could promote greater use of the family automobile since it would be available to other family members during the day. Some effort should be made to answer these questions so as to fully anticipate the overall, or net, result.

Freeway systems, in the near future may be operated like a manufacturing process with closed-loop control. This will keep the V/C ratio below the point where congestion begins. There may be, however, some congestion generated by this process on surface streets. Where operational controls are planned, some judgement should be made as to their effect on pollutant emissions.

Obviously, perturbations in the network are similar to the ripples from a stone thrown into a pool. The effect may be felt some distance away, but the strength diminishes with distance. Accordingly, judgement must be used in deciding where to draw the line im making traffic estimates.

TRAFFIC GROWTH FACTORS

A traffic network is seldom static. Even when new facilities are absent, some development of vacant land continues to occur at a slow rate. When a transportation improvement is completed, traffic growth normally accelerates. Since traffic growth creates more mileage and, consequently, more pollutant emissions, the effect must be analyzed.

The AASHO Policy on Geometric Design(8) although somewhat out of date, defines three areas in which traffic growth occurs. It is helpful to think of traffic divided in this manner even though it may not be estimated or reported in these terms. The following paragraphs are direct quotes from the AASHO Policy:

"Traffic Increase". After the current traffic volume is established, it then is necessary to determine the traffic likely to use the improved highway in some future year selected for design. The current traffic, which represents only the existing trips that would be made over the improvement when opened to traffic, will be increased by normal traffic growth, generated traffic, and development traffic."

"Normal Traffic Growth. Normal traffic growth is the increase in traffic volume due to general increase in number and usage of motor vehicles. Since 1900 motor vehicle ownership has grown steadily. In 1915 there were approximatly 2 1/2 million automobiles in use in the United States. By the end of 1961 motor vehicles registration had reached 76 million. Motor vehicle travel has followed a similar trend, increasing from approximately 50 billion vehicle miles in 1920 to about 740 billion in 1961 and rough estimates indicate that it will be above 930 billion vehicle miles in 1980. Indications are that the general upward trend will continue into the near future. Some day, doubtless, traffic will level off. But to estimate the year, or even the decade, when the time will come is impossible. Despite predictions in the past that motor vehicle travel would reach a saturation point, traffic has relentlessly pushed through each expected ceiling."

"Figure 8 shows total estimated motor vehicle travel, rural, urban and total, in the United States, 1930-61. Except for the pronounced dip during the World War II years (1941-46), the general upward trend has been maintained. Since 1946, when travel returned approximately to normal, the yearly increase in travel has been greater than during any other equivalent period of time."

"Estimated rural and urban travel, the lower curves in figure 8, indicate that on a national basis the trends for the two types of areas, were about the same until 1948 when rural travel increased at a more rapid rate than urban travel. Since 1956 or 1957 the trends have been about the same."

"From the past trend, the motor vehicle travel may be projected to the future year for which the design is to be made. This may be done by plotting a curve of total vehicle miles against years, similar to figure 9 and projecting the curve by judgment to the year desired. It also may be done by plotting separate curves for population, number of vehicles per unit of population, and average miles of travel per vehicle based on gasoline consumption. The product of these three values taken from the curves for the year chosen for design gives the total vehicle miles of travel for that year. The dashed line in figure 9 is a travel forecast for a selected State evolved from such an analysis."

"For any one facility, estimates for the increase in normal traffic should be based on trends and estimates for the region. State or locality in which the highway is situated. This can be done by applying the percentage increase taken from a trend curve, as in figure 9 to the current traffic volume. For example, based on the trend of figure 9 for a current year of 1961 and design year of 1971, the increase in normal traffic is (4.2 - 3.4) divided by 3.4 = 24 percent. Then for a current ADT volume (1961) of 6000 vehicles, the normal traffic growth would be 0.24 x 6000 = 1440 vehicles."

"Generated Traffic. Generated traffic consists of motor vehicle trips (other than by public transit) that would not have been made if the new facility had not been provided. Generated traffic is made up of three categories; new trips not previously made by any mode of travel; trips that previously were made by public transit; and trips that previously were made to a different destination, but for which the change is attributable to the attractiveness of the improved highway and not to change in land use. Regardless of the reason for generated traffic, the net result is traffic increase on a given improvement. Most of this traffic develops within the first year or two after a new highway is opened."

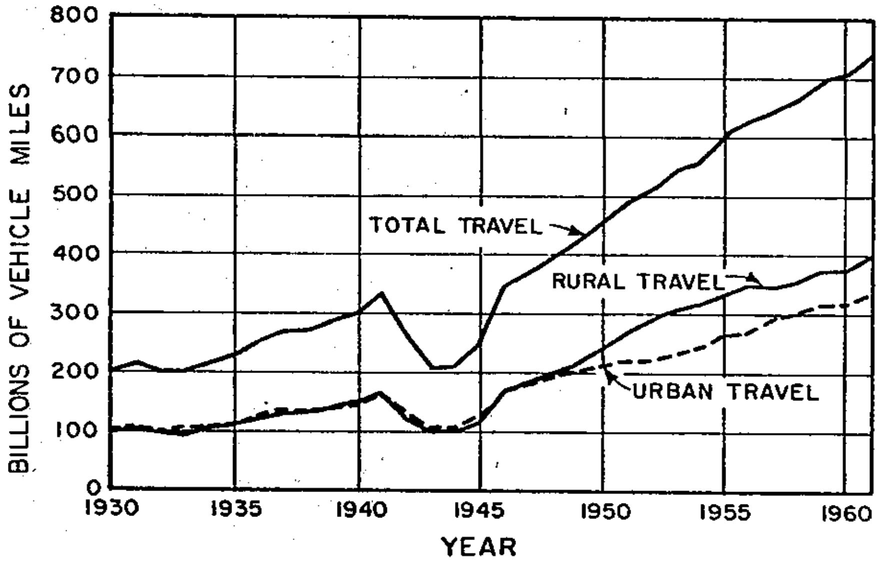

Fig. 8 TOTAL MOTOR VEHICLE TRAVEL-UNITED STATES

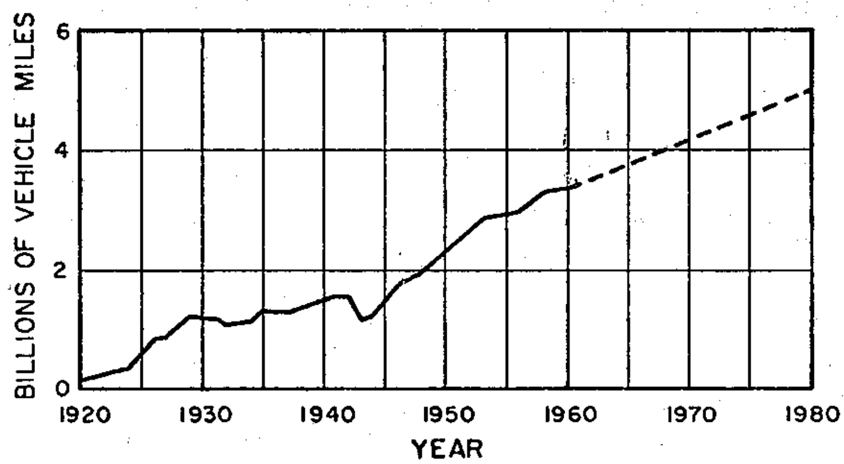

Fig. 9 TOTAL MOTOR VEHICLE TRAVEL AND FORECAST
SELECTED STATE

"Thus generated traffic is the traffic created initially or within a reasonable period of time as a result of a new or more attractive highway. This traffic is distinct from normal traffic growth, previously discussed, and distinct from traffic that may be generated due to more rapid development of land near the highway than elsewhere, discussed separately below."

"The amount of generated traffic that materializes on any one improvement may vary considerably, depending primarily on the type and extent of improvement, character of other highways in the area, and land use. Improvements that are small in scope or those that do not materially improve operating conditions are apt to produce little generated traffic. On the other hand, traffic on a new highway to a resort development may be composed almost entirely of generated traffic. A type of highway on which it is pleasant, relaxing and safe to drive as a controlled access highway, generates more traffic than one with frequent interference, annoyance, and hazard. Arterial highway improvements that lead to destinations with adequate parking facilities usually create many more new trips than similar improvements where the parking situation is critical. Highway improvements in areas where public transit or other modes of transportation are inadequate generally produce more generated traffic than those in areas where other transportation means are, or are made attractive. As in the case of attracted traffic the amount of generated traffic may depend upon the capacity and the volume on existing roads that are relieved by the improved highway."

"Little information is available on generated traffic. There are not many examples, and often traffic is measured so that the increase called generated traffic includes other forms of traffic growth."

"Two examples in Washington, D. C. show traffic volumes generated by new bridges. Generated traffic, as distinct from attracted traffic, was obtained in each case by comparing traffic volumes on all river crossings before and after the improvement, taking seasonal traffic variations into account. Traffic generated immediately upon opening the improvements was about 4 to 6 percent, respectively."

"In Interstate analysis, factors for generated traffic ranging from 30 to 60 percent with an average of 45 percent were given. These appear extremely high even allowing that freeways generate much more traffic than noncontrolled access highways. The large percentage may be due in part to trips resulting from new developments along the road that take place simultaneously with the construction of the road."

"In establishing the traffic volume for the design of a highway, generated traffic should be included as a component even though it may be based upon judgment only. For most rural highways generated traffic as herein defined is likely to run 5 percent or over but probably rarely as much as 25 percent."

"<u>Development Traffic</u>. Development traffic is that due to improvement on adjacent land over and above the development which would have taken place had not the new or improved highway been constructed. In Interstate analysis this has been referred to as the "L" factor or the percentage increase over a Statewide increase to allow for greater development along a highway than throughout the State. This component of future traffic, unlike that of generated traffic, continues to develop for many years after a new facility is constructed. Increased traffic due to normal development of adjacent land is included in normal traffic growth, but experience with many improved highways indicates that adjacent land is developed more rapidly than land elsewhere. The traffic resulting therefrom should be accounted for in estimating future traffic volume."

"Maps showing existing land use, existing land improvements, existing zoning, proposed zoning changes, if any, and probable future land use are needed to estimate future land development. When the location and type of a proposed highway are indicated on such maps, estimates may be made of probable changes in land use and likely developments on adjacent land. For example, it is more likely that vacant land will be built upon than additional improvements made on land already occupied with buildings.

Land near railroads and watercourses is likely to encourage industrial development, and high ground is likely to be improved with homes. Past trends in these regards and the opinions of local business men are valuable guides."

"Once the future land use is forecast, the likely number of trips resulting from each type of development, and the proportions of these trips between various points of origin and destination, are estimated. From analyses of travel-habit studies, it is possible to estimate roughly the number of trips that each kind of development will produce and what proportions of these trips will be made to various types of areas. The resulting number of these future trips and their desire lines between different zones can then be shown, and traffic volume components can be assigned to the proposed facility in a manner similar to that used for assigning existing origin and destination data. It also is necessary to make a rough estimate as to the proportion of the computed volume which can be considered as already included in normal traffic growth."

"Rural highways leading to a recreation area which is within reasonable distance of an urban area might need a large development. Recreation and travel to recreation areas are increasing rapidly and a factor to allow for such abnormal increase may be appropriate in some locations. Where such recreation areas are subject to seasonal or weekend use separate calculations for design hourly volumes for such times may be necessary."

"When a rural highway is a freeway, as in Interstate analysis, there is likely to be development traffic resulting from abnormal development along the freeway, near interchanges or along cross-roads having interchange with the freeway. A factor to allow for traffic above the resulting from normal land development due to such abnormal land development may be appropriate."

"In strictly rural areas that are well removed from cities and villages, this type of traffic growth is apt to be less significant than in the near urban areas. In some instances, it can be neglected altogether with the assumption that the normal traffic growth accounts for traffic due to all land development. In urban and suburban areas, and in rural areas between a city and satellite communities, traffic resulting from rapid development of adjacent land generally will be significant."

"The method of obtaining development traffic may not be precise and the volumes obtained are only approximate, but in many cases the volume from this cause is appreciable. The omission of this item in estimating future traffic might explain why the volumes for a number of prominent improvements in the past proved to be underestimated."

In view of the foregoing discussion it is easy to understand the thesis that traffic predictions which serve to warrant new highways could become self-fulfilling prophecies. This could occur due to the opening up of new areas for development which might then create traffic and bring the new facility up to capacity.

At this point, the traffic network has to be examined very carefully for changes which could be expected to occur with and without the new or improved facility. Area masterplans, land use, and demographic projections must be considered, the temper of the populace with regard to development must be judged, and the historical attitudes of the elected officials toward rezoning and land use variances must be examined. This is the weakest link in the traffic estimate procedure, but it must be carried through in the best possible manner.

If the freeway is not built and the community is development-minded, expressways and high-speed arterials might be built with local funds. In some areas urban mass transit may cause development. The net effect on air quality, in cases like these, may be no different whether the freeway is built or not. In any case, development with and without the new highway facility should be estimated so that the two situations may be compared.

TIME FRAMEWORK FOR TRAFFIC ESTIMATES

Estimates of traffic for use in air quality predictions should cover a time period which commences when the study is made (Now) and ends 20 years after the estimated time of completion (ETC) of the facility. The "Now" value provides the local citizen with a familiar baseline for reference which he can then use to subjectively evaluate future predicted changes.

TRAFFIC PARAMETERS AND ENVIRONMENTAL EFFECT

The environmental effects of traffic emissions can be divided into two broad categories, mesoscale effects and microscale effects. The mesoscale effects are felt in terms of overall air quality, or pollutant burden, throughout that portion of the air basin affected by the alterations in the traffic network. The volume of air affected depends upon confining topography, inversion heights, and wind speed. Background levels of downwind air quality are a direct result of upwind emissions.

The traffic parameters used for mesoscale air quality predictions are daily vehicle miles (DVM) and average trip speed. The average trip speed reflects the amount of acceleration, deceleration, and idle modes of engine operation, as well as cruise conditions. A knowledge of average trip speed coupled with the amount of miles traveled at that speed enables a quantitative determination of pollutant emissions from a particular stretch of road. It is also necessary to know the percentage of heavy duty vehicle (HDV) traffic (over 6,000#GVW).

Since a smaller percentage of average daily traffic (ADT) occurs during periods of possible congestion (Figure 4), and the rest of the traffic is free flowing, the use of steady-state speed emission relationships should be used to calculate the pollutant burden emitted by freeway mileage. Even greater detail could be obtained by using average trip speeds for peak hour mileage and steady-state speeds for the remainder. At the present time, however, emission factors are insufficiently refined for this procedure and the resultant calculations(6) are conservative.

Microscale effects are limited to the immediate highway corridor and are felt only by the immediately adjacent downwind receptors. Pollutant concentrations in these areas are raised above background levels by the highway line source emissions. Since the highest concentrations must be pinpointed, it is necessary to obtain peak hour traffic to calculate emissions at that time. Again, the percentage of heavy duty vehicles must be known as well as the speed for various times of the day.

In the microscale analysis, close examination of traffic volumes and speeds for various times of the day and seasons of the year may be important. Anomalous local traffic patterns and meteorological phenomena may combine to provide peak hour pollutant concentrations at other than peak traffic hours. Occasionally, strange patterns may be found(9).

Traffic information provided for the microscale analysis must encompass time periods which will allow comparison with ambient air quality standards. Examination of carbon monoxide, for example, means that peak one hour traffic as well as maximum 12 hour traffic must be available for the analysis.

MINIMUM TRAFFIC ESTIMATE REQUIREMENTS

The minimal information required for a fairly comprehensive air quality study is shown in graphic and tabular form in Figures 10 through 17. Figure 10 is an information matrix which ties the graphs in figures 11 through 16 to the analysis scheme and to the various levels of the traffic network.

The graphic presentation in figures 11 through 16 is for explanatory purposes only. It is not intended that these graphs are the only, or the best, way to present traffic information. They do, however, serve in this report as an excellent method for illustrating traffic requirements.

Figure 17 is a tabular arrangement of data for the proposed highway facility for both microscale and mesoscale analyses. This form of presentation could be used to replace all that in Figures 11, 15, and 16, and some of that in Figure 14.

The development of surface traffic data is not shown in Figure 17. It is very important that surface traffic information be developed, however. This is needed, as outlined earlier, to analyze air quality if the facility is not built. It also serves to define air quality improvement along surface arterials when traffic is transferred to a highway facility.

<table>
<tr><th colspan="2" rowspan="2">TRAFFIC PARAMETERS</th><th rowspan="2">PROPOSED HIGHWAY FACILITY</th><th colspan="2">SURFACE TRAFFIC*</th></tr>
<tr><th>WITH NEW FACILITY</th><th>WITHOUT NEW FACILITY</th></tr>
<tr><td rowspan="2">MESOSCALE AIR QUALITY</td><td>DAILY VEHICLE MILES</td><td>①②④⑤⑥ ⑦ ⑧ ⑩ (FIGURE 11)</td><td>②③④⑥ ⑦⑧⑩ (FIGURE 12)</td><td>② ④⑥ ⑦⑧⑩ (FIGURE 13)</td></tr>
<tr><td>OVERALL SPEED</td><td>⑫ ⑬ (FIGURE 14) (CURVES 1 & 2)</td><td>⑪ (FIGURE 14 – CURVE 3)</td><td>⑪ (FIGURE 14 – CURVE 4)</td></tr>
<tr><td rowspan="2">MICROSCALE AIR QUALITY</td><td>PEAK HOURLY VOLUME</td><td>⑦ ⑧ ⑭ ⑮ (FIGURE 15 & 16)</td><td colspan="2" rowspan="2">⑯</td></tr>
<tr><td>SPEED AT PEAK HOURLY VOLUME</td><td>⑫ (FIGURE 14) (CURVE 2)</td></tr>
</table>

Fig. 10 TRAFFIC INFORMATION MATRIX FOR AIR QUALITY PREDICTIONS

*Surface traffic for the mesoscale analysis is that traffic from all streets in the feeder area - This represents a grid source of pollutants which affect the burden in the air basin.

①Attracted Traffic (use for new facility)
②Existing Traffic (use for improved facility)
③Diminished Traffic (use for surface streets) AASHO
④Normal Traffic Growth
⑤Generated Traffic Definitions Daily
⑥Development Traffic (based on existing land use plane) Vehicle
⑦Change in Traffic Due to Future Land Use Changes
⑧Change in Traffic Due to Urban Mass Transit Facility Miles
⑩Percentage of Heavy Duty Vehicles (HDV)
⑪Average Trip Speed
⑫Average Peak Hour Trip Speed Speed
⑬Average Trip Speed for Free-Running Facility
⑭Daily volume Volume
⑮Hourly % of Daily Volume
⑯This information is not usually available - It would define surface traffic from arterials parallel and immediately adjacent to the proposed facility which would be strongly influenced by that improvement. These represent a line source of pollutants which has an effect on nearby receptors.

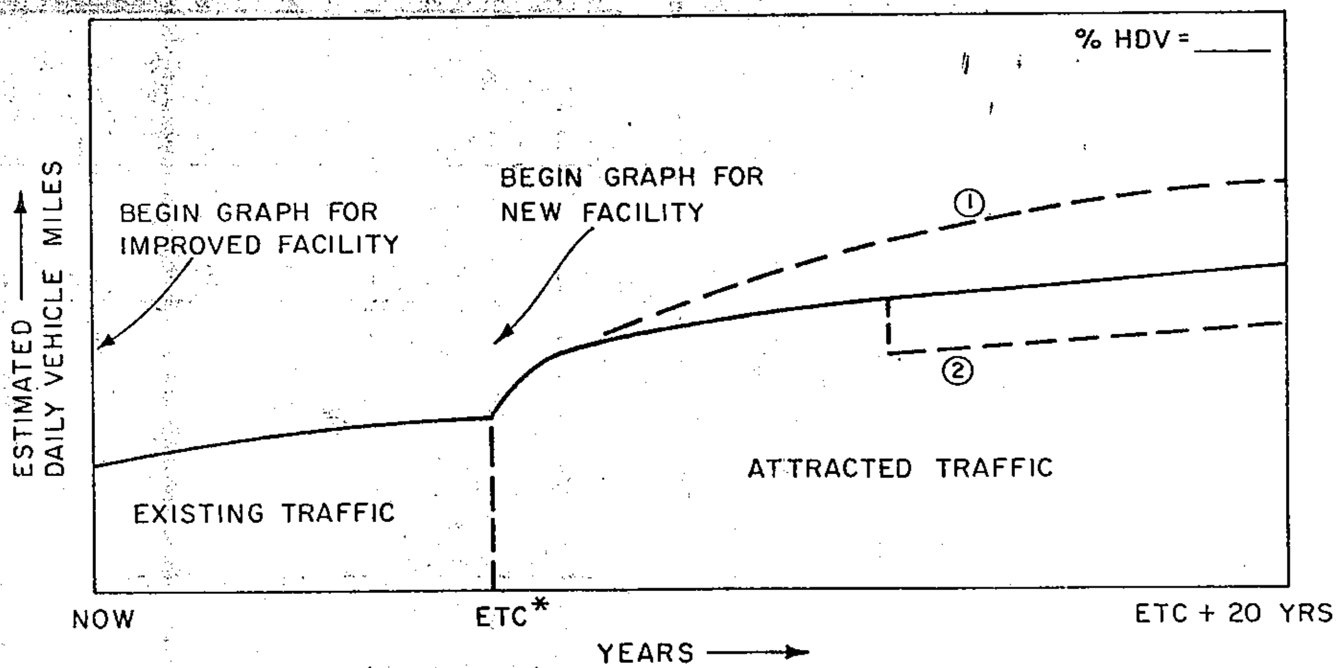

Fig. 11 ESTIMATED TRAFFIC ON NEW OR IMPROVED FACILITY

*Estimated Time of Completion
① Change in Traffic Due to Possible Land Use Change
② Change in Traffic Due to Urban Mass Transit Facility

If inbound and outbound traffic are substantially different, the directions must be analyzed separately.

The solid line should estimate total traffic and will reflect normal growth and generated traffic.

Changes in land use predicted by local planning agencies should be reflected also in the solid line estimate. The dashed line estimate should show what could happen if these land use plans should be violated in the direction of population density increases.

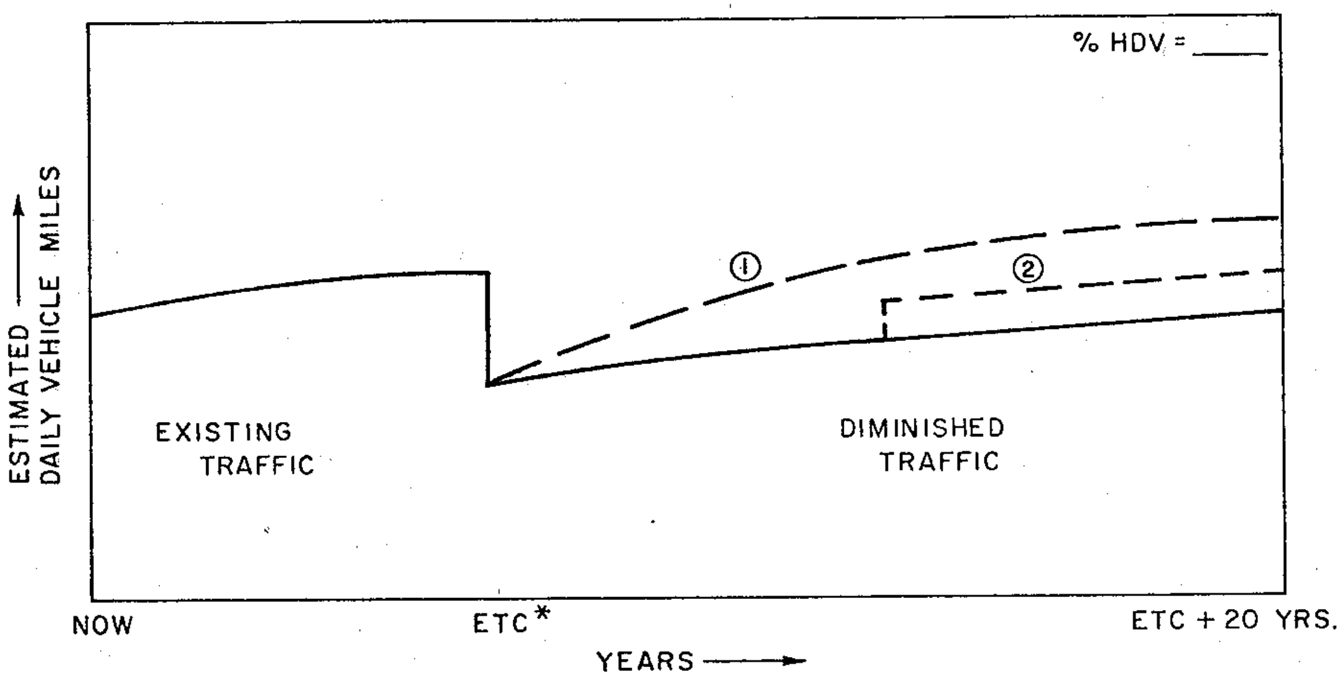

Fig. 12 ESTIMATED TRAFFIC ON SURFACE NETWORK WITH HIGHWAY FACILITY IN OPERATION

*Estimated Time of Completion
① Changes in Traffic Due to Possible Land Use Change
② Changes in Traffic Due to Urban Mass Transit Facility

The solid line should estimate total traffic and will reflect normal growth in terms of planned land use. The dashed line should show what could happen if land use plans should be violated in the direction of population density increases.

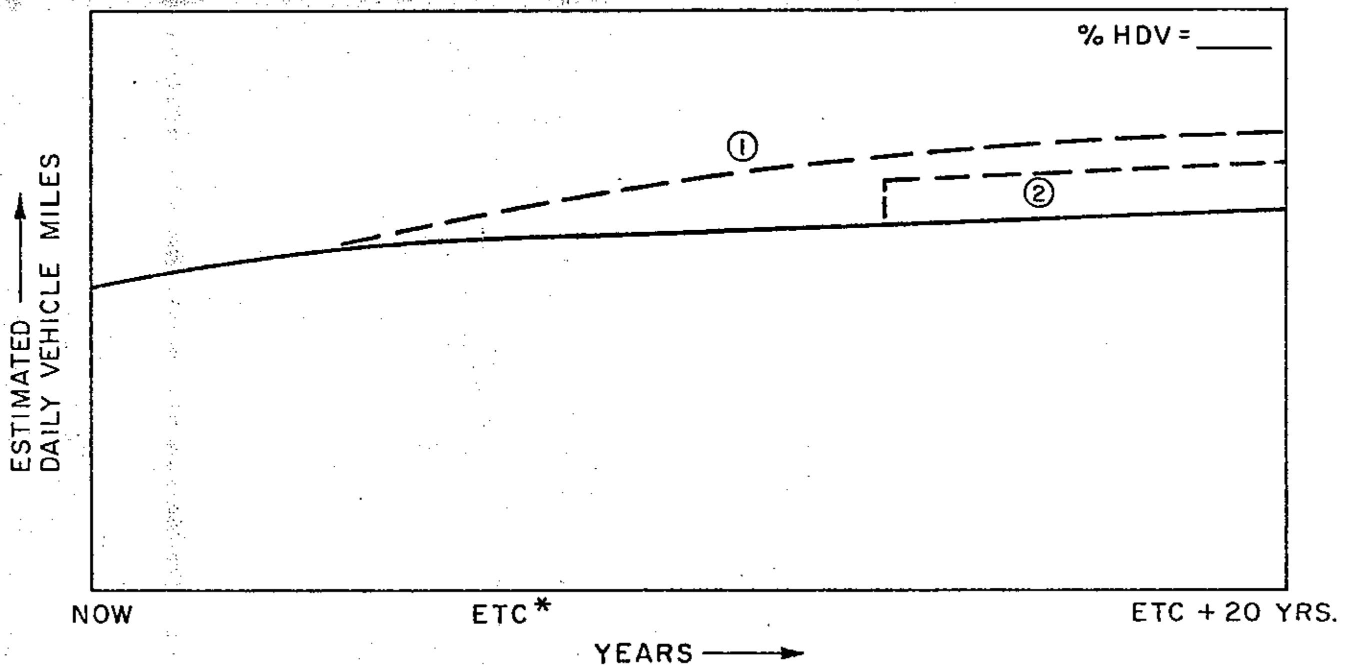

Fig. 13 ESTIMATED TRAFFIC ON SURFACE NETWORK IF NEW FACILITY IS NOT CONSTRUCTED

*Estimated Time of Completion
①Changes in Traffic Due to Possible Land Use Change
②Changes in Traffic Due to Urban Mass Transit Facility

The solid line should estimate total traffic and will reflect normal growth in terms of planned land use. The dashed line should show what could happen if land use plans should be violated in the direction of population density increases.

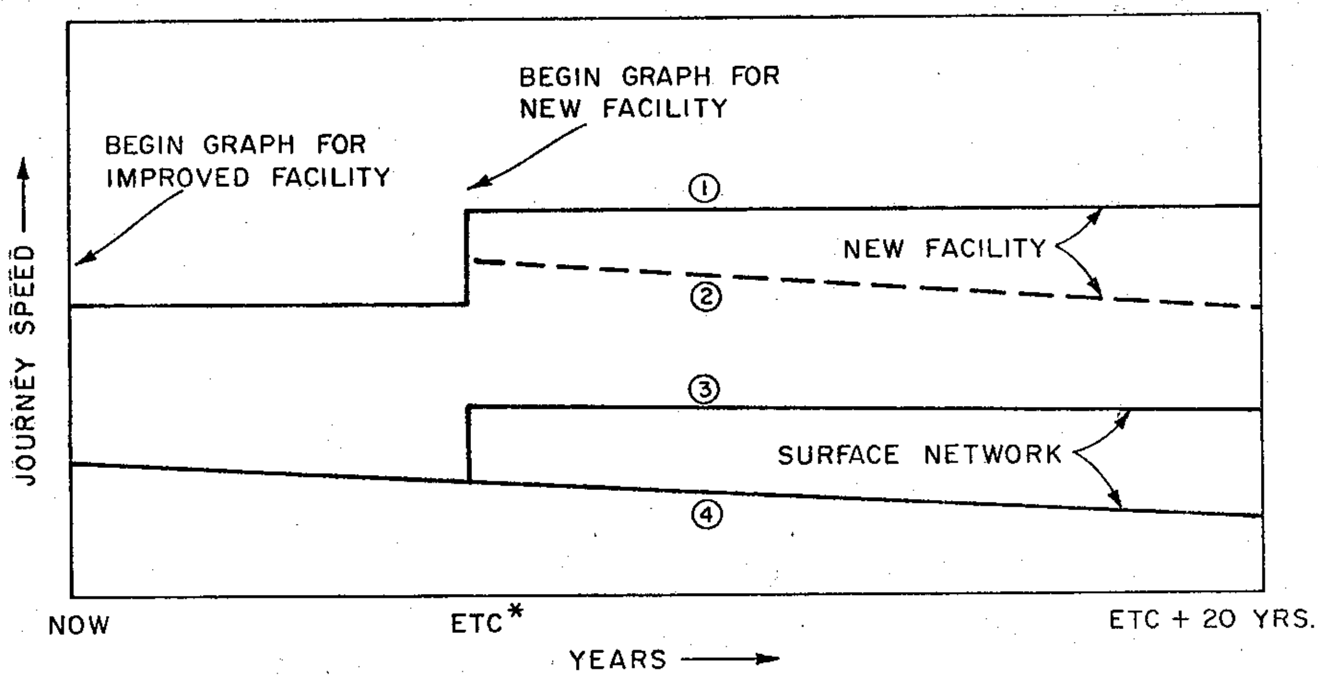

Fig. 14 ESTIMATED CHANGES IN AVERAGE TRIP SPEED

*Estimated Time of Completion
1 Curve Reflecting Free-Running Facility for Design Life
2 Curve Reflecting Worst-Case Peak-Hour Traffic
3 Surface Traffic with New Facility in Operation
4 Surface Traffic If New Facility is Not Constructed

Speed estimates should also reflect changes caused by construction of urban mass transit systems.

If inbound and outbound traffic are substantially different, the directions must be analyzed separately.

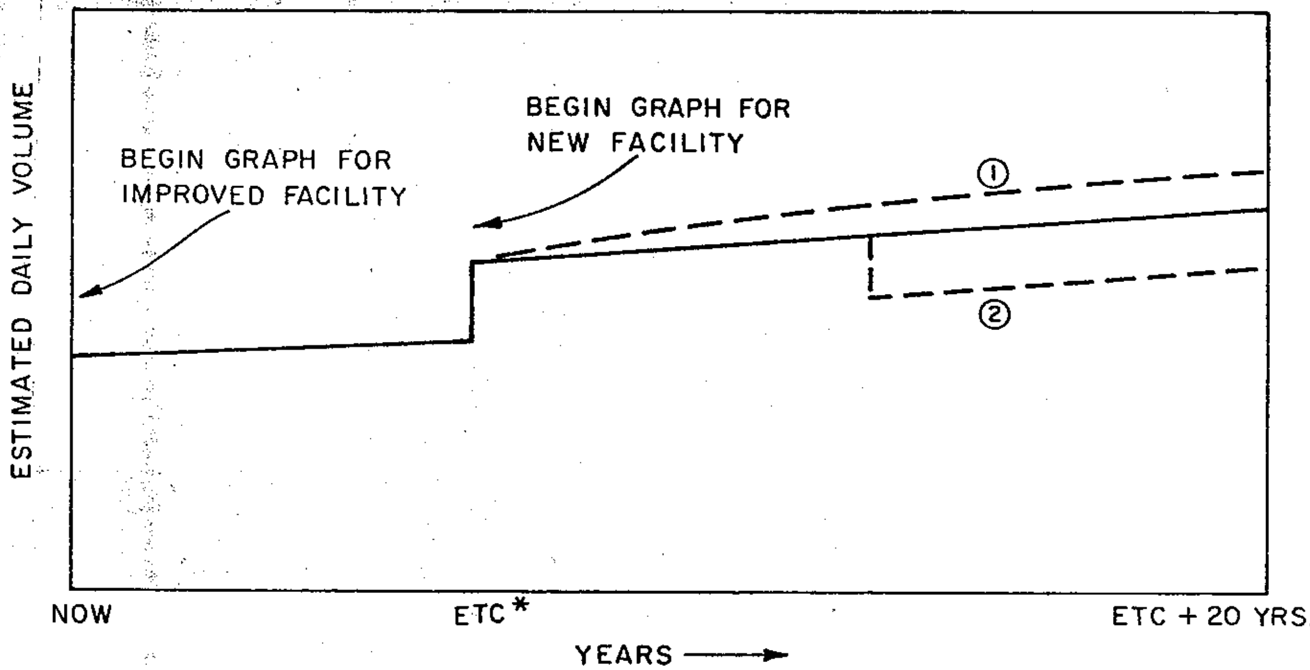

Fig. 15 ESTIMATED DAILY VOLUMES VERSUS TIME FOR NEW OR IMPROVED FACILITY

*Estimated Time of Completion
① Changes in Traffic Due to Possible Land Use Change
② Changes in Traffic Due to Urban Mass Transit Facility

If daily volumes are expected to vary considerably between week-days and week-ends or between summer vacation months and the rest of the year, separate graphs should be drawn. This also applies where large differences exist between inbound and outbound traffic.

The solid line should estimate total traffic and will reflect normal growth and generated traffic.

Changes in land use predicted by local planning agencies should be reflected also in the solid line estimate. The dashed line estimate should show what could happen if these land use plans should be violated in the direction of population density increases.

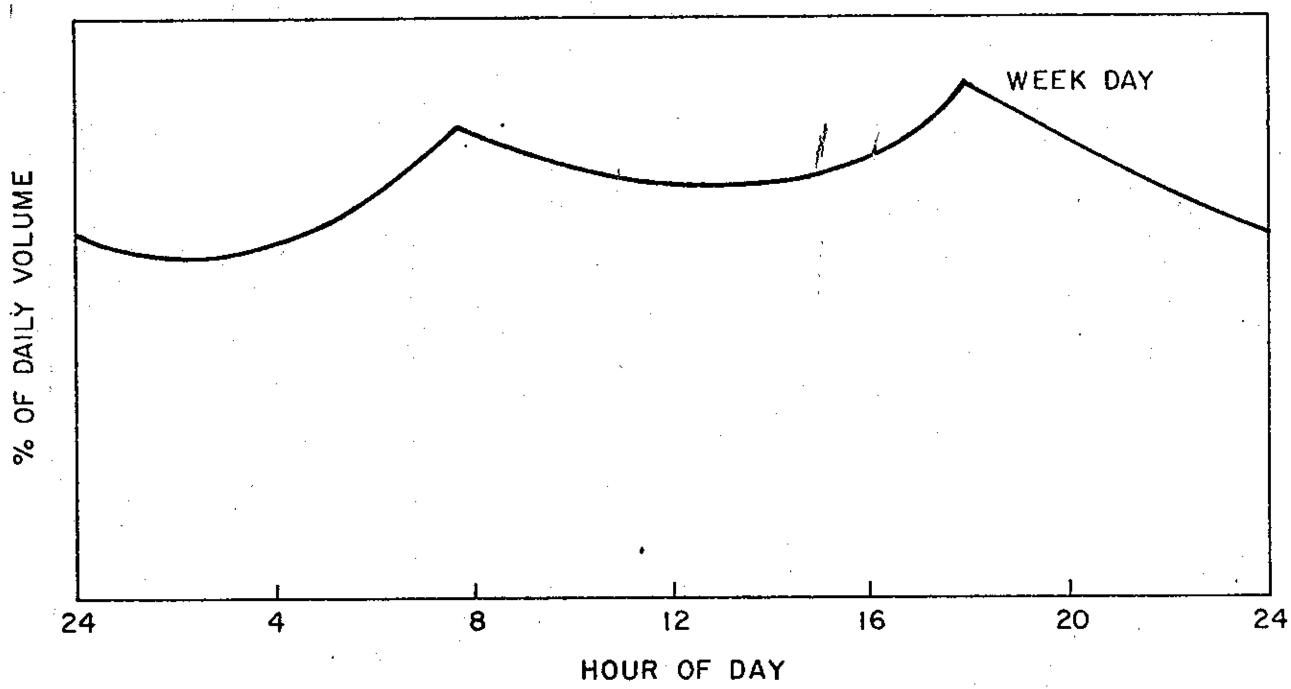

Fig. 16 AVERAGE 24-HOUR VEHICLE TRAVEL DISTRIBUTION ESTIMATED FOR NEW FACILITY

When week-end traffic patterns are substantially different from week-day patterns, separate graphs should be drawn. This should also be done for areas where vacation months traffic (June-Sept.) creates substantially different patterns than those for the rest of the year. The same reasoning applies where large differences exist between inbound and outbound traffic.

YEAR OF ESTIMATE________________

LENGTH OF IMPROVEMENT________________ % HEAVY DUTY VEHICLES__________

TIME*	VOLUME		SPEED		% ADT	
	INBOUND	OUTBOUND	INBOUND	OUTBOUND	INBOUND	OUTBOUND

Fig. 17 ESTIMATED TRAFFIC ON NEW OR IMPROVED FACILITY

*Time in 15 minute increments during peak hours and one hour increments elsewhere.

Separate tables should be made up to fully characterize traffic during the 20+ year study period. Separate tables should also show effects of land use changes, mass rapid transit, week-days vs. week-ends, seasonal traffic changes, and etc. where necessary.

BIBLIOGRAPHY

Cited

1. Highway Research Board, "Highway Capacity Manual," Washington, D. C. 1965, (Special Report 87).

2. Makigami, Yasuji; Woodie, L.; and May, A. D.; Bay Area Freeway Operations Study - Final Report (Part 1). University of California, Berkeley, Institute of Transportation and Traffic Engineering, August 1970, (Special Report).

3. "Effect of Speed on Emissions," California Air Resources Board, Los Angeles, California, March 1971.

4. Rose, A. H.; Smith, R.; McMichael, W. F.; and Kouse, R. E.; "Comparison of Auto Exhaust Emissions From Two Major Cities," U. S. Public Health Service, Cincinnati, Ohio, 1964.

5. Martinez, J. R.; Nordsieck, R. A.; and Eschenroeder, A. Q.; "Morning Vehicle-Start Effects on Photochemical Smog," General Research Corporation, Santa Barbara, California, June 1971.

6. Beaton, J. L.; Skog, J. B.; and Ranzieri, A. J.; "Motor Vehicle Emission Factors For Estimates of Highway Impact on Air Quality," State of California, Department of Public Works, Materials and Research Department, Air Quality Manual No. CA-HWY-MR657082S(2)-72-10, April 1972.

7. Karl Moskowitz, Personal Communication.

8. AASHO, "A Policy on Geometric Design of Rural Highways," Washington, D. C., 1965.

9. Johnson, W. F.; Dabberdt, W. F.; Ludwig, F. L.; and Allen, R. J.; "Field Study For Initial Evaluation of an Urban Diffusion Model For Carbon Monoxide," Stanford Research Institute, Menlo Park, California, June 1971.

Uncited

1. "Control Techniques for Carbon Monoxide, Nitrogen Oxide, and Hydrocarbon Emissions From Mobile Sources," HEW, NAPCA, Washington, D. C., March 1970.

2. Myers, P. S.,; Automobile Emissions - A Study in Environmental Benefits versus Technological Costs," paper presented to Institute of Mechanical Engineers, Coventry, England, November 1969.

3. Highway Research Board, "Data Requirements for Metropolitan Transportation Planning," Washington, D. C., (Special Report 120).